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LINCOLN LABORATORY

THE LINCOLN TERMINAL SYSTEM:
CIVIL APPLICATIONS

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ABSTRACT

In January 1970, the M.I.T. Lincoln Laboratory undertook, with Air Force sponsorship, the exploratory development of an automated training system to meet the urgent need for more cost-effective technical training in the Services. Basically, this resolves to the need for an economic means of supporting individualized self-instruction. It is clear that such a capability would have application outside of military or technical training. This report discusses how the concepts and supporting technology currently under development at Lincoln Laboratory might be extended to meet areas of concern in civil education, including vocational training, continuing education, manpower development, rehabilitation, and self-improvement.

Accepted for the Air Force
Joseph R. Waterman, Lt. Col., USAF
Chief, Lincoln Laboratory Project Office

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THE LINCOLN TERMINAL SYSTEM: CIVIL APPLICATIONS

I. BACKGROUND

To date, technology has had little impact on the public school system, and there is reason to believe that it will not make a substantial contribution to conventional classroom instruction in the near future. Certainly to the extent that our schools exist to "countenance and inculcate the principles of humanity ... general benevolence ... and all social affections ...,"* they would seem to be immune from technological attack or assistance. However, there is a growing awareness that the educational crisis in this country is not simply a "crisis in the classroom"; it is also a crisis of unmet needs among all those who have left the classroom and are now becoming aware of what they do not know, of what they need, and of what they are unable to get because they have never learned how.

The present system has been ineffective in responding to these demands for training both in school and beyond. We believe it will continue to fail. It is not economically feasible to set up the number and variety of conventional vocational training and adult education classes that would be necessary to meet the tremendous range of individual needs. Furthermore, competent teachers are seldom available locally, and for adults it is often difficult, if not impossible, to schedule classes around the competing demands of work and family. Individual self-education is the only true solution to this problem, but most people do not have access to the necessary instructional materials nor do they possess the skills that are required for self-instruction using conventional materials and techniques.

* Constitution of the Commonwealth of Massachusetts.

What is needed is a system that will deliver, on demand, instructional material that is tailored to the present knowledge, the present needs, and the capabilities of any individual requesting such support.

It must handle high-quality graphics. There are important areas of learning in which complex schematics, such as circuit diagrams and detailed mechanical layouts, play an essential role — as do photographs, including color photographs. (CRT displays, for example, lack the required dynamic range and resolution.) The system must have an audio capability. Reading is a complex skill, and not all prospective students will be highly proficient readers. It must be possible to supplement textual material with oral explanations.

These are essential features, but they are not sufficient. The system must be interactive if it is to support students with average, or below average, learning skills and in the absence of highly trained instructors. There must be provision for continual diagnostic testing that will provide to the student the knowledge of progress that is necessary not only to maintain motivation but to permit self-pacing.

Lastly, the student must be able to control the moment-to-moment rate at which material is presented. He must be able to speed it up or slow it down. He must be able to scan, to stop, to go back, and to review. (Training films and TV are generally not satisfactory just because they cannot be rate-adjusted in this sense by the individual viewer.) Moreover, there should be individual options not only in pacing but in the sequence, style, and substance of presentation. Continuing education is largely adult education, and it must be recognized that students will have relatively fixed cognitive styles and preferences. Instructional material must match the student as well as specific skill objectives or career goals.

In summary, effective vocational training and continuing education require highly individualized instruction. Such instruction puts demands on both the instructional material and on the means by which it is delivered. The greater the variety of material available, the more nearly it will be possible to tailor it to individual needs. This is true, however, only if the distribution system makes the appropriate material available when it is needed by either the instructor or the student. In terms of information system design, what is required

is fast, random access to a large store of material that includes voice quality audio, high resolution graphics, and the procedures, response interpretation, and control logic that are necessary to support interaction with the student.

II. THE LINCOLN LABORATORY PROGRAM

The Lincoln Laboratory program in Educational Technology was established with Air Force support in January 1970 as a research and development program to meet the requirements outlined above. We believe that the present program has established the feasibility of developing a system that will support individualized learning outside of the usual classroom environment and will yield major savings in training time and costs.

A. A Delivery System

The Lincoln Terminal System (LTS) is based on microfiche technology. This is a particularly attractive medium because it affords a very high quality graphical-pictorial capability and an extremely economical means of publishing, distributing, and storing lesson materials. In addition to these features, the Laboratory has demonstrated the feasibility of storing and recovering audio and lesson logic, as well as graphical information, from a standard size microfiche and has developed the technology for production of audio-graphic microfiche.

This has enabled the development of a system concept (illustrated in Fig. 1) that includes a carousel projector for fast access to many hundreds of fiche, a keyboard to support student responding and fiche selection, and, ultimately, a self-contained logical processor that will interpret student responses and lesson logic, stored digitally with graphical and audio material to control the lesson sequence.*

A laboratory version of this system has been constructed and will be field tested in early 1972 in cooperation with the 3380th Technical School, USAF Air Training Command. Further research and development will be needed,

* The principal features, rationale, and present implementation of the Lincoln Terminal System are described in more detail in Annex 1.



Fig. 1. Artist's conception of the Lincoln Terminal System. A more advanced design will include a self-contained logical processor and front projection for greater flexibility in use.

however, to design hardware with appropriate performance and reliability that could be procured in quantity at a reasonable cost. We have proposed to the Air Force an extension of the present program to accomplish this, as well as to extend field experience and to generate additional instructional material.

B. Lesson Development

Instructional material is a key consideration in any educational system, and it is often argued that technology can have little impact on training and education because it can only improve the distribution of instructional material; it cannot contribute to the development of that material and it cannot assure that the material is properly used once it is distributed. In the case of the LTS, these assertions are clearly not true. In the first place, the system does facilitate the generation of lesson material and course development. Individualized instruction implies modularity in training materials. Since it is not feasible to develop full length courses to match the idiosyncracies of each student, a course must be thought of as a sequence of units selected from a larger set to

provide what is needed by a particular student at a particular time. The larger set would include units at different "levels" to match differences in ability and to permit flexibility in the construction of a short, narrow course with very specific educational objectives or a longer, broader course which allows more freedom to the student in the selection of content and the establishment of goals.

Microfiche is ideally matched to this requirement for modularity. It permits inexpensive publication and distribution of small units — 10 to 30 minutes of instruction — and encourages the development of lesson material by classroom instructors or specialists who would not normally author an entire course. A carousel terminal with many such units available in seconds facilitates individualization and permits ready comparison of alternative presentations of particular topics and some degree of course optimization.

The most important interaction between the system and lesson development, however, derives from the fact that the lesson logic is included on the fiche as an integral part of the lesson module. The LTS can thereby insure that the material is used at least as the author intended it to be, for the instructional procedures and techniques are an integral part of the material. In this sense, some of the classic functions of the teacher are transferred to the lesson development process and, as a rule, course authors will be teachers or must work closely with teachers.

It is anticipated that lesson development would take place at regional centers. The detailed functions and possible operation of a Lesson Development Center (LDC) are described more fully in Annex 2. Basically, the Center is responsible for the development and validation of new lesson material and the conversion of existing material to meet the needs of the populations served by the Center. However, because LTS gives course authors responsibility for instructional procedures as well as content, it is important that the LDC be closely associated with any existing research on instructional techniques as well as field operations. It is thus the natural locus of continuing responsibility for system evolution, and offers a means for bridging the gap between system development, test and evaluation, and operational deployment.

III. THE CIVIL ENVIRONMENT

A. A Typical LTS Installation

The LTS is adaptable to a variety of learning environments both diffuse and concentrated. At present, we consider a basic unit of the system to be from 5 to 15 instructional terminals in a single location, operating under the control of a small computer. The computer serves to monitor and record student actions and to control the presentation of information. There are, of course, instances where this unit cluster of terminals may not be completely satisfactory. In remote locations, one can foresee the need for a stand-alone terminal which might not have the recording and monitoring capability associated with a basic group but would perform comparably in other respects. We also see need for the capability of removing a terminal to a location up to a few miles from the group computer. Such an operation might be in support of an on-the-job or "hands on" training program which is integrated with an academically based course. Both forms of remote operation can be accommodated.

In general, however, clusters of terminals are preferred in order to facilitate management and maintenance. These terminal clusters could be located in local libraries, public school buildings, or even National Guard armories. The LTS makes it possible to merge a variety of educational system needs and suggests that such distinctions as have been made between rehabilitation, vocational training, or technical training in the Armed Services can and should become blurred.

It would be reasonable to organize these basic units on an area basis. An area center would function as a Lesson Development Center (see Annex 2) and would also maintain a staff of subject matter experts for consultation services as well as curriculum generation. We anticipate that the material available at each terminal will, in time, be sufficiently rich so that most students will have infrequent need to consult with an instructor or specialist. However, when the need for consultation does arise, the student simply picks up the telephone and calls the Center. The specialist assigned to that skill area reorients the student exactly as a classroom teacher would. Both student and specialist

have at hand an LTS terminal containing identical material and, with an elementary telephone data set, either student or specialist can direct the other's console and call up material to guide and expedite the discussion.

The LTS technology places few constraints on the intellectual or physical organization of an area. An area could be centered around a university in support of an open enrollment program; an area could be associated with other institutions such as prisons or VA hospitals; or it could be a self-sustaining and widely dispersed system to deliver career and vocational training to remote and sparsely settled geographic regions. The LDC should be able to serve all classes of users equally well.

B. Establishing the System

It has generally been difficult to introduce innovation into the educational system and just as difficult to propagate even after successful demonstration. This difficulty stems from the fact that proposed innovations have so often simply been substitutes for existing techniques, teaching aids, or curriculum, and there is little incentive to change something that works however inefficiently. Moreover, educational innovation has often been so closely associated with the style of an individual teacher as to preclude duplication.

The LTS, on the other hand, meets a basic need that is not now being met. Installations can be easily adapted to meet the special requirements of particular environments or populations. An area system can be duplicated in whole or in part. It can be scaled up or down without economic penalties. A particular virtue is that new areas contribute to the data base, either by supporting the development of new instructional material or, by a simple extension of the market, reducing the cost per student for lesson development.

The point to be made is that if a pilot area is established by, for instance, the Office of Education, it can be easily replicated or extended by state or local agencies or by agencies such as the Veterans Administration, outside of USOE. Growth funding should be facilitated by the fact that the LTS affords a new capability and is not competing with older, already established operations.

With all this in mind, we would recommend the installation of a pilot area as the initial step in system evolution. The target population should be diverse

enough to test the range of capability of the system, but narrow enough to prevent dilution of effort on the part of the program management group. The geographic area covered must be large enough to be realistic (and to support an appropriate student population) but small enough to minimize financial risk. Ten groups of 5 to 10 consoles each should represent a reasonable balance between coverage and cost.

Most of the console groups should be installed in public high schools where a management structure exists and where they would be available not only to high school students but to citizens of the community and industrial trainees. Consideration should be given to the installation of console groups in a VA hospital, an industrial plant, a large library, and a technical institute. One Lesson Development Center would serve all users in the pilot region, and all users would be connected to the LDC with leased telephone/data lines.

The major problem to be faced is the acquisition of an adequate quantity and variety of educational material. However, if it can be demonstrated that curriculum development and distribution will ultimately represent a small fraction of the total cost of administering and operating the system, initial operation should not require a tremendous amount. Our estimate is that material for approximately 1000 hours of instruction would be sufficient.

Curriculum material for starting up the pilot system could be selected from the library of Air Force training material. The Aerospace Educational Foundation has already examined this material and identified more than 80 courses, representing 26,000 instructional hours, that would be of value to the public sector. The list includes courses in health sciences, communications, ecology, automobile and aircraft maintenance, and civil engineering. (Annex 3 is a collection of course charts for a few of these courses.) The courses are generally well designed, tested, and validated. Most of them are in modular form and could be adapted to the LTS format with minimal effort.

Air Force material will not, of course, meet all the anticipated needs or populations that might be served by an LTS area. For the long run, we see at least two regions of expansion that should be explored in the pilot system; these are higher education and what we will call "recreational learning." The LTS has been developed to meet urgent needs for vocational-technical training.

The extent to which such a system is effective in educational areas that are not so specifically skill-oriented, such as art appreciation or engineering concepts, is open to investigation. It is important and urgent that such studies be carried out in light of the demand for and difficulties associated with the support of open enrollment at the college level.

Recreational learning is similar to higher education in the sense that it is not specifically career oriented or, at least, not related to a specific career. It involves general cultural material such as "The Great Books," and it also involves the entire "do-it-yourself" area — how to paint a house, how to repair a watch, how to predict the weather. As LTS terminals become available, this sort of material will inevitably become available, but it is important that it be demonstrated at a very early state in the pilot operation. The possibility of using leisure time for learning can be a long-term, major source of public and financial support for the development and proliferation of a system that serves many other needs as well.

ACKNOWLEDGMENT

The work reported here represents a joint effort of the entire staff of the Educational Technology Program. The general concept of the LTS and its applications have evolved from many hours of discussion with W.P. Harris, David Karp and R.C. Butman.

ANNEX 1

THE LINCOLN TERMINAL SYSTEM (LTS)

The LTS is a "distributed" information system. All lesson specific information -- audio and visual displays and branching logic -- is located at the student terminal. This makes it possible to load terminals with different lessons so that there is no competition for resources (except terminals) among students operating within the system. This also makes it possible to design a model of the LTS with its own processor for stand-alone operation. Because there is a natural exchange of "amount of control information on the fiche" for "complexity of processing," fairly elaborate interpretations of student response can be achieved with minimal hardware costs.

Even with minimal processor capability, such a system can perform quite sophisticated functions. Response interpretation (program) as well as branching control tables (data) can be read into the processor from any microfiche frame. The file management problem is obviated because there is no off-line bulk storage to be concerned with and because information is pre-programmed to be directly available on the fiche when it is needed, in conjunction with the appropriate visual and auditory displays. The LTS prototype, at 1000 bits of storage per frame (e.g., 5 seconds at 200 baud), 12 frames per fiche and 750 fiche, has a capacity of one-half million words of read-only storage per student terminal. One machine with a simple local processor or a few machines tied to a small computer represents a very powerful CAI system by current standards.

A. LTS-3

The LTS-3 is the present embodiment of the Lincoln system concept. It uses microfiche as the basic medium for storing and distributing instructional material. Microfiche is a 4- by 6-inch photographic card most commonly produced with 60 photographic images per fiche. At this density, the images have extremely high resolution and half-tone and continuous-tone reproduction are very satisfactory. Color is feasible.

Development work at Lincoln Laboratory has made it possible to include audio information on the same fiche, as illustrated in Fig. A-1. A dual projection system is used, with one image the usual video and with one image a spirally recorded sound track, similar to those laid down at the edge of a sound motion picture film. This is projected onto a diode reading head which is capable of acquiring, tracking along the spiral, and detecting the audio signal. At the present stage of development, a single fiche is limited to 24 images, or 12 lesson frames. We believe that this density can be increased by changes in the format and improvement of the reader; it should eventually be possible to approximate the COSATI standard density (60 images, 30 lesson frames.)

The audio record at present contains 30 seconds of audio. Brief bursts of digital data which contain the logic for lesson sequencing may be interleaved along the audio spiral in any reasonable manner. Speech is highly intelligible and of high enough quality for prolonged listening.

Up to 750 fiche may be loaded into the carousel of a modified Image Systems, Inc., CARD reader to which a second projection system and optical phonograph have been added as shown in Fig. A-2. Access from frame-to-frame on a single fiche is less than one second; access to a frame on any other fiche takes less than 6 seconds.

In addition to the projector-reader, there is a keyboard with which the student responds to lesson material, and a logical processor which controls the operating sequence according to the student's response and the lesson logic prescribed by the author.

The system configuration that will be operated at Keesler Air Force Base consists of five terminals (projector-reader and keyboard) controlled by a small computer. The computer serves the processor function for all terminals, interpreting student responses and the control logic supplied by the author to command the next instructional frame. In addition, the computer records and analyzes student performance data.

B. Keyboard Control

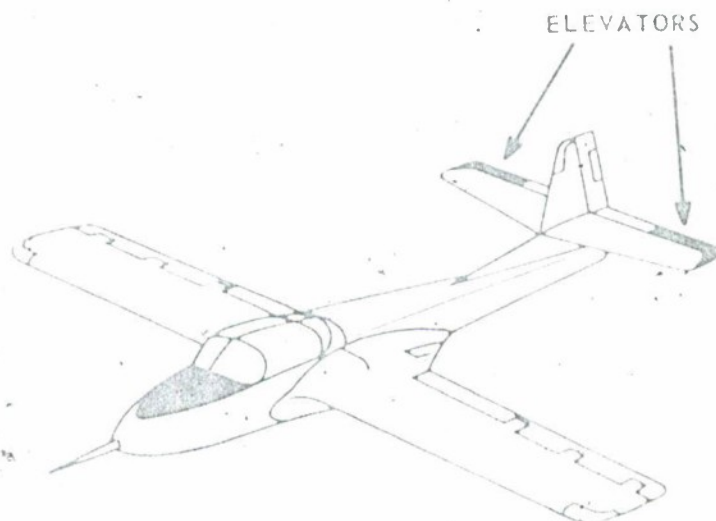
LTS lessons consist of a set of information frames that the student experiences in a sequence that depends on both the author's program and the student's



Fig. A-1. A lesson fiche from Air Training Command course on Air Traffic Control. Audio images are on the left.

COURSE: 3ABRZ7230
LESSON: 001
FRAME: 023

THE ELEVATORS ARE MOVABLE PARTS OF THE HORIZONTAL STABILIZER. THEY ALLOW THE PILOT TO CONTROL THE UP AND DOWN MOVEMENT OF THE AIRCRAFT. BY MOVING THE ELEVATORS UP, THE AIRFLOW OVER THE ELEVATORS' TOP SURFACE IS CHANGED AND THIS FORCES THE TAIL DOWN AND THE NOSE UP. WHEN YOU MOVE THE ELEVATORS DOWN, THE AIRFLOW WILL PRODUCE A REVERSE EFFECT. THAT IS, THE TAIL GOES UP AND THE NOSE GOES DOWN. COMPARE THE DIFFERENCE, THEN ANSWER THE QUESTION BELOW.



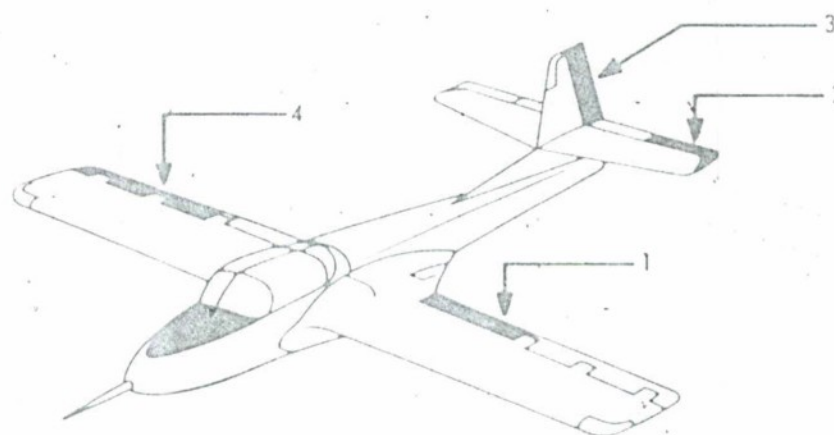
WHAT IS THE FUNCTION AND LOCATION OF THE ELEVATORS?

- (1) USED TO AID IN CONTROLLING MOVEMENT OF THE AIRCRAFT IN CLIMB OR DESCENT AND LOCATED ON THE HORIZONTAL STABILIZER.
- (2) USED TO ASSIST IN ENTERING AND RECOVERING FROM TURNS AND LOCATED ON THE VERTICAL STABILIZER.

COURSE: 3ABR27230

LESSON: 001

FRAME: 024



MATCH THE ABOVE NUMBERED MOVABLE CONTROL SURFACES WITH THE CORRECT NAME.

START WITH THE FIRST MOVABLE CONTROL SURFACE LISTED BELOW AND WORK DOWN.

ENTER A NUMBER FOR EACH MOVABLE CONTROL SURFACE BEFORE YOU PRESS GO-ON.

() FLAP

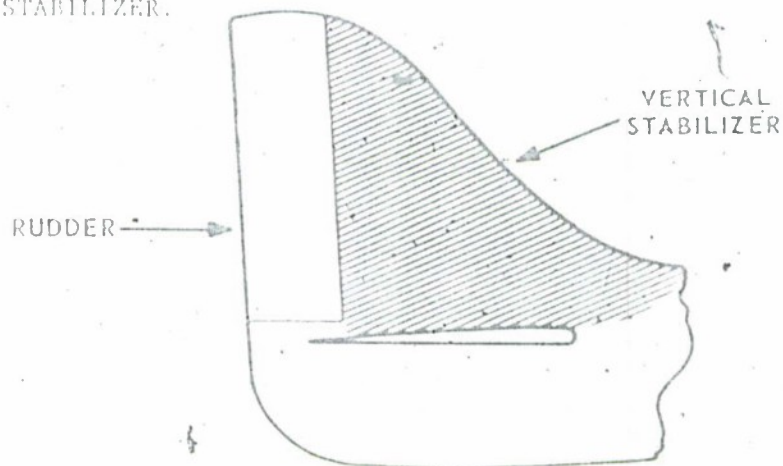
() RUDDER

() AILERON

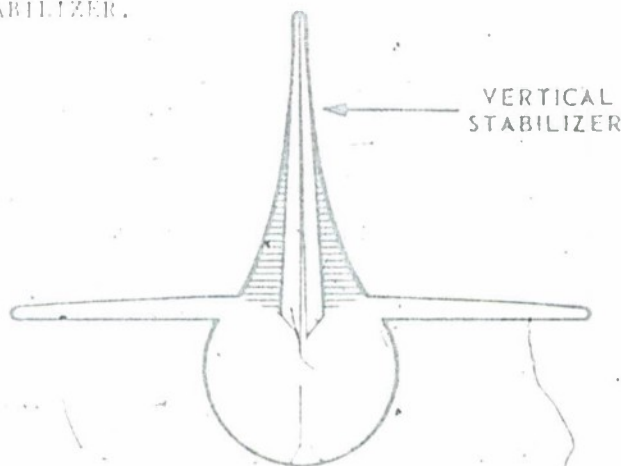
() ELEVATOR

COURSE: 3ABR27230
LESSON: 001
FRAME: 025

IN THIS ILLUSTRATION THE SHADED PART OF THE TAIL SECTION DEPICTS A SIDE VIEW OF THE VERTICAL STABILIZER.



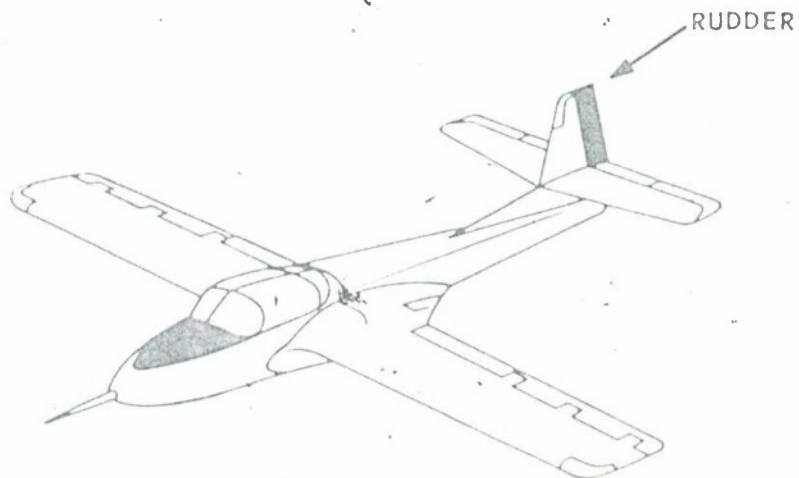
IN THIS ILLUSTRATION THE SHADED PART OF THE TAIL SECTION DEPICTS A REAR VIEW OF THE VERTICAL STABILIZER.



AS YOU CAN SEE, THE VERTICAL STABILIZER IS THAT PART OF THE TAIL SECTION THAT IS STRAIGHT UP AND DOWN. THE SIDE VIEW ILLUSTRATES HOW THE RUDDER IS HINGED TO THE VERTICAL STABILIZER.

STUDY THE ABOVE INFORMATION, THEN PRESS GO-ON.

COURSE: 3ABR27230
LESSON: 001
FRAME: 026

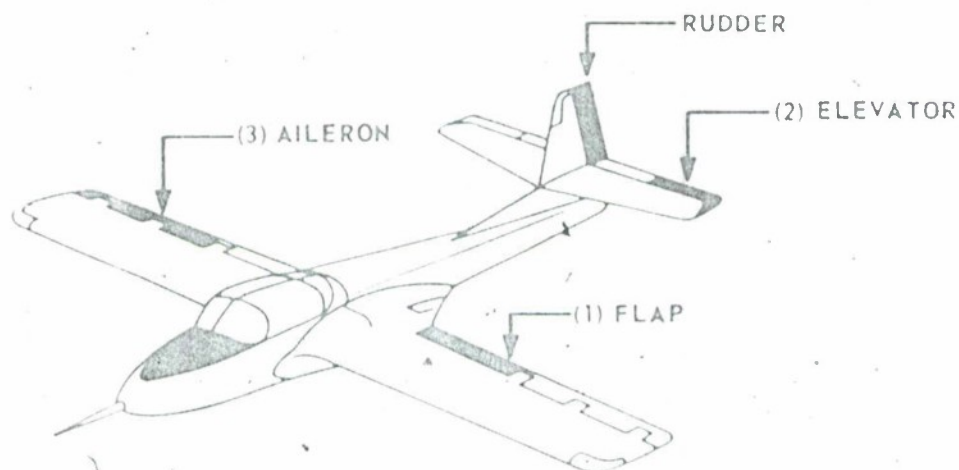


WHAT IS THE FUNCTION OF THE RUDDER?

- (1) FOR BANKING AND TURNING THE AIRCRAFT.
- (2) TO CONTROL MOVEMENT OF THE AIRCRAFT IN CLIMB OR DESCENT.
- (3) TO ASSIST IN ENTERING AND RECOVERING FROM TURNS.

COURSE: 3ABR27230
LESSON: 001
FRAME: 027

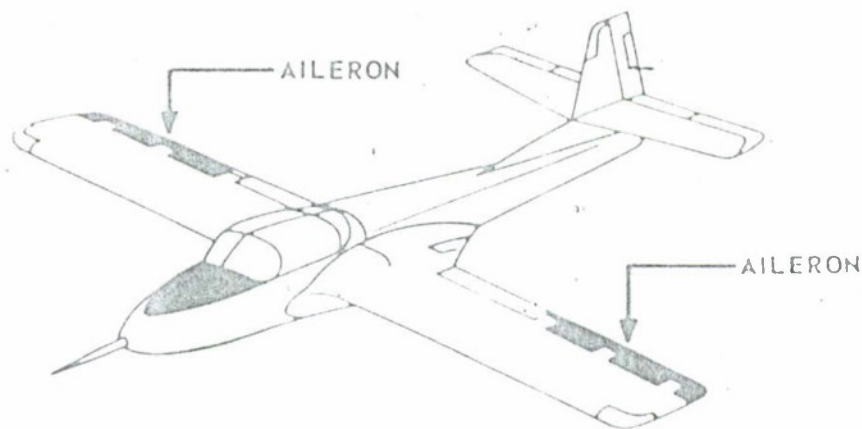
THE FOUR MOVABLE CONTROL SURFACES OF AN AIRCRAFT ARE IDENTIFIED BELOW. YOU MAY NOW SELECT A DIFFERENT CONTROL SURFACE TO STUDY.



PRESS THE NUMBER THAT APPEARS BESIDE YOUR CHOICE. IF YOU HAVE COMPLETED ALL FOUR PARTS, PRESS NUMBER 4 AND GO-ON.

COURSE: 3ABR27230
LESSON: 001
FRAME: 028

AILERONS ARE MOVABLE CONTROL SURFACES HINGED AT THE TRAILING EDGE OF THE WING. AS YOU CAN SEE, THEY ARE LOCATED NEAR THE WING TIPS. STUDY THEIR LOCATION VERY CAREFULLY. AFTERWARD, SEE IF YOU CAN CORRECTLY ANSWER THE QUESTION AT THE BOTTOM OF YOUR SCREEN.



WHAT ARE THE FUNCTIONS OF THE AILERONS?

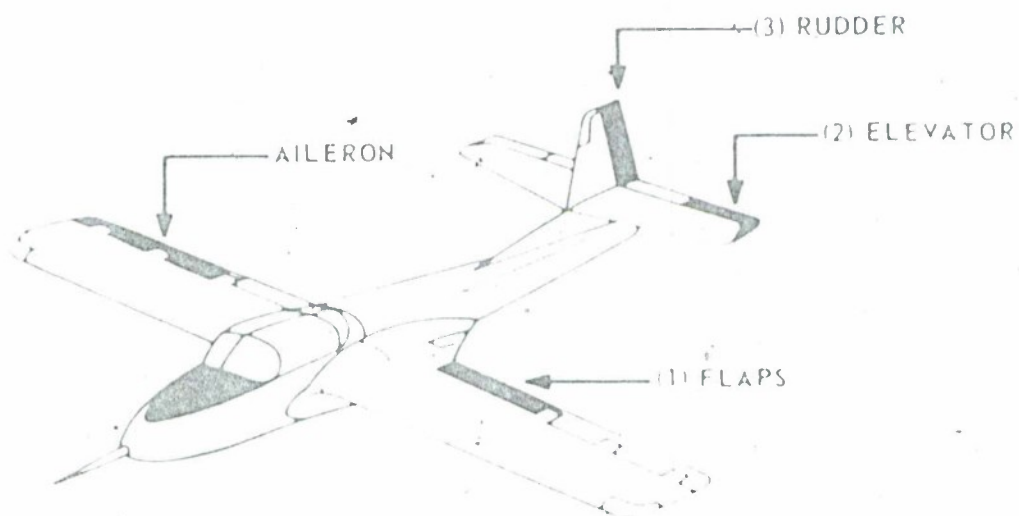
- (1) TO BANK AND TURN THE AIRCRAFT.
- (2) TO CONTROL MOVEMENT OF THE AIRCRAFT IN CLIMB OR DESCENT.
- (3) TO ASSIST IN ENTERING AND RECOVERING FROM TURNS.

COURSE: 3ABR27230

LESSON: 001

FRAME: 029

FOUR MOVABLE CONTROL SURFACES OF AN AIRCRAFT

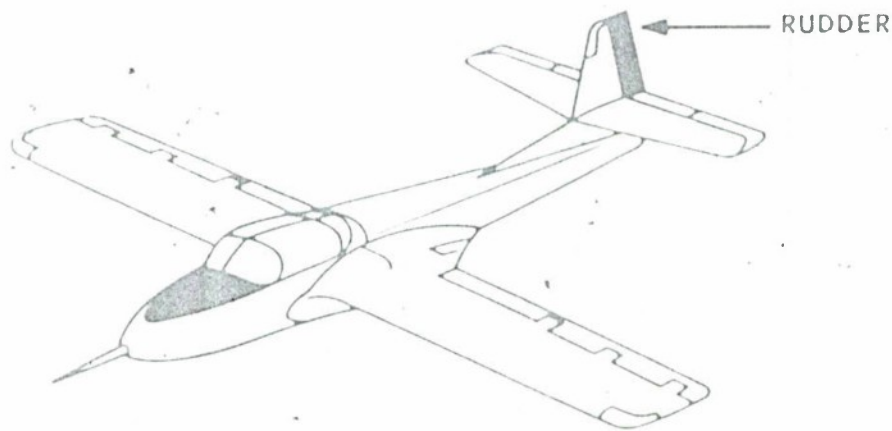


PRESS THE NUMBER THAT APPEARS BEFORE EACH SURFACE, IN ORDER.

ALL FOUR PARTS, PRESS THE NUMBER 4 AND GO ON.

COURSE: 3ABR27230
LESSON: 001
FRAME: 030

THE RUDDER IS THE MOVABLE AIRFOIL ATTACHED TO THE VERTICAL STABILIZER, WHICH IS A PART OF THE TAIL ASSEMBLY. ITS MAIN PURPOSE IS TO ASSIST IN ENTERING AND RECOVERING FROM TURNS. COMPLETE THE STATEMENT BELOW:

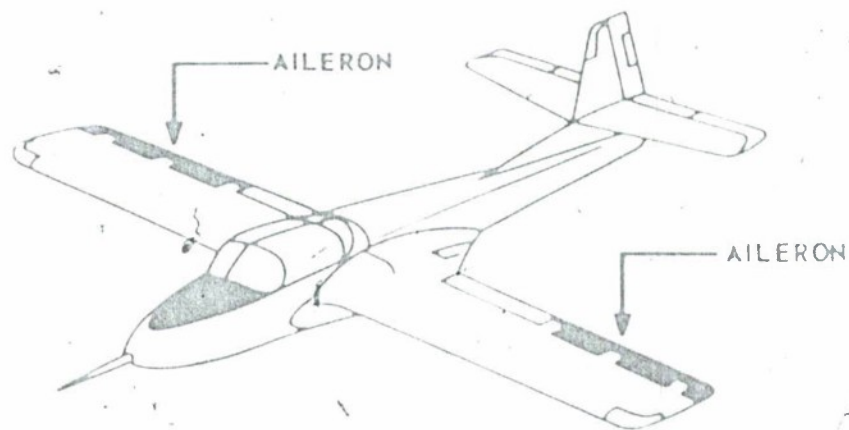


THE FUNCTION OF THE RUDDER IS TO:

- (1) BANK AND TURN THE AIRCRAFT.
- (2) CONTROL MOVEMENT OF THE AIRCRAFT IN CLIMB OR DESCENT.
- (3) ASSIST IN ENTERING AND RECOVERING FROM TURNS.

COURSE: 3ABR27230
LESSON: 001
FRAME: 031

AILERONS ARE HINGED AT THE TRAILING EDGE OF EACH WING NEAR THE WING TIP. THEY ARE PRIMARILY USED WHEN AN AIRCRAFT IS IN A TURN. BOTH AILERONS MOVE AT THE SAME TIME, BUT IN OPPOSITE DIRECTIONS. THIS ACTION FORCES ONE WING DOWN AND THE OTHER WING UP. NOW TRY TO ANSWER THE QUESTION BELOW:

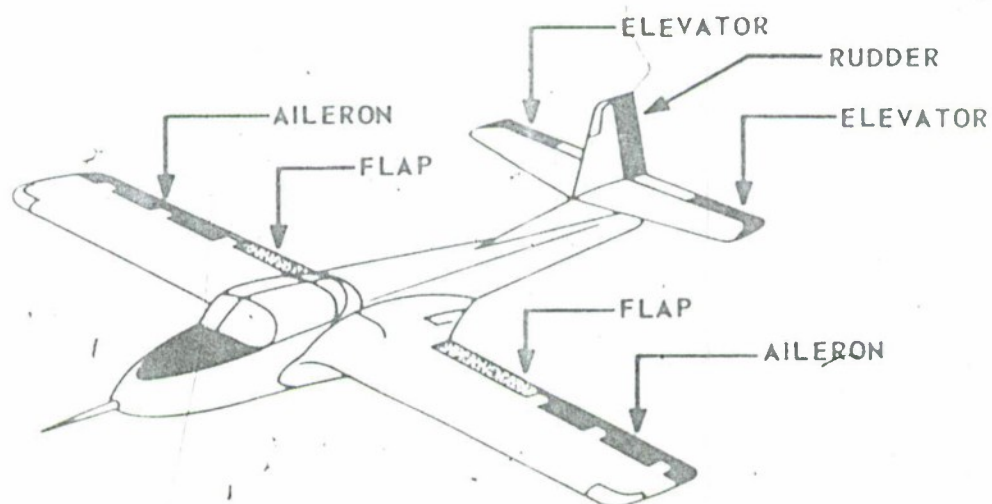


WHAT IS THE FUNCTION OF THE AILERONS?

- (1) TO BANK AND TURN THE AIRCRAFT.
- (2) TO CONTROL MOVEMENT OF THE AIRCRAFT IN CLIMB OR DESCENT.
- (3) TO ASSIST TAKEOFF AND REDUCE SPEED ON LANDING.

COURSE: 3ABR27230
LESSON: 001
FRAME: 032

STUDY THE ILLUSTRATION A MOMENT, THEN PRESS GO-ON.



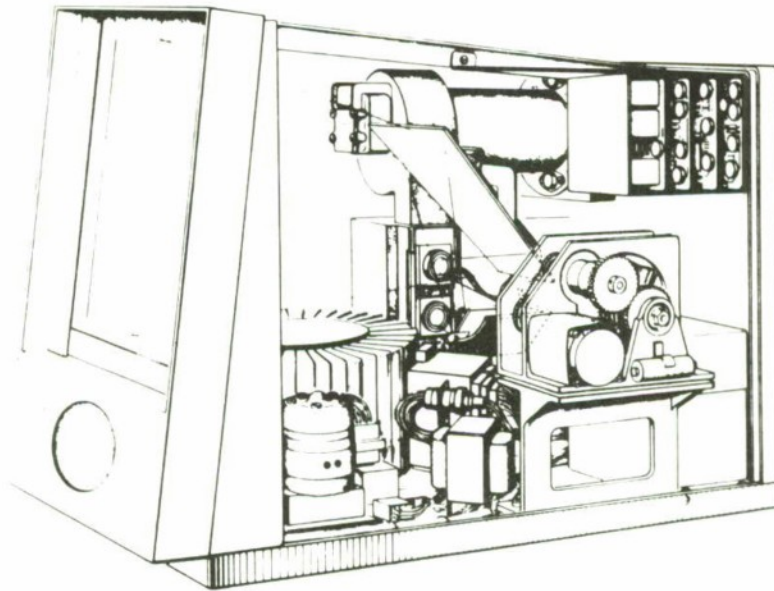


Fig. A-2. Development model of projector-reader.
Fiche are stored in carousel at left.

responses. A frame may communicate instructions, facts, problems, and/or questions via visual and/or auditory messages to which the student responds by selecting among prescribed alternatives. The alternatives include responses that allow the student to conduct his own review of frames previously covered or that access supplementary material, either reference or expanded instructional material.

Students interact with the system by means of a keyboard. The keyboard is completely programmable and, as there is control logic associated with each frame of each lesson, the course author has complete freedom in the assignment of functions to keys and in the interpretation of student responses.

Figure A-3 represents the keyboard as presently laid out for LTS-3. This particular configuration was derived from experience with LTS-1.* It has been kept very simple but has proven to be surprisingly flexible and powerful.

*See Lincoln Laboratory Quarterly Technical Summaries: Educational Technology, 15 June 1970, 15 September 1970, 15 December 1970.

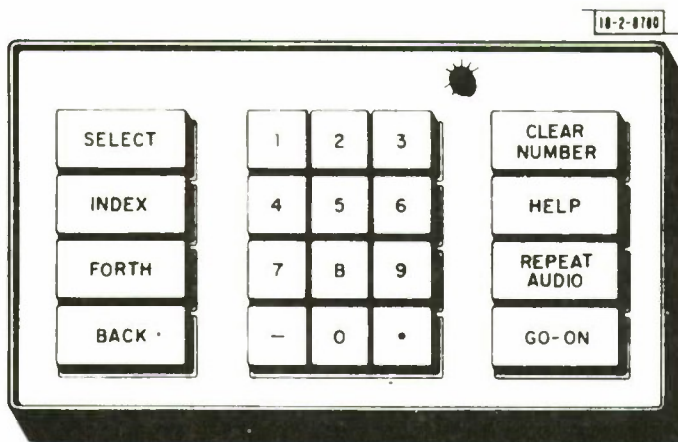


Fig. A-3. LTS-3 keyboard.

From the point of view of the student, the keyboard is divided into three sections. Each of the four keys at the left causes a new frame to appear.

INDEX shows a frame that lists places in the current lesson that can be selected. A number is shown with each topic listed.

SELECT is used to move to a point. Enter a number, from INDEX or a lesson frame, and press SELECT. The selected frame will appear.

BACK and FORTH are used to move back and forth through a list of frames already worked in the lesson. BACK moves one frame backward on the list; BACK/BACK, two frames on the list; etc. FORTH moves one frame forward. It will stop at the most recent frame covered. Frames entered with INDEX, SELECT, FORTH and BACK are not recorded on the BACK and FORTH list. The Error Light (see Fig. A-3) comes on when BACK reaches the beginning of the list and FORTH to end. It also comes on if a number followed by SELECT is not acceptable.

When a student is responding to a frame, he uses one of the three keys at the right – HELP, REPEAT AUDIO, or GO-ON. To the student, a press of GO-ON always means "I am ready for more information – more sound or an entire new frame." It will always cause new information to appear. In some cases, the machine has asked for information from the student and expects it in the form of a number (e.g., a multiple choice question). It will not go on to a new frame unless an acceptable number has been entered.

The audio message may come in parts separated by pauses. During a pause the audio is stopped. It will start again when GO-ON is pressed. When the audio is complete, GO-ON causes a move to a new frame. Three or more rapid presses of GO-ON will cause an advance to the next frame unless a number response has been requested.

REPEAT AUDIO causes a replay of the audio from the start. It has no other effects.

HELP is a button that may be pressed if there is doubt about how to respond. Pressing HELP may cause a new frame to appear with further instruction. It can be used to signal the instructor.

There are also other ways in which the student may expand on the material presented to him. For instance, technical terms may be subscripted, in which case entering the appropriate number and pressing SELECT will move the student to a descriptive frame or frames. BACK would, under these circumstances, return the student to the main lesson sequence.

The operation of the number keys in the center of the keyboard is fairly obvious. Numbers are entered as a series of key pushes. Numbers are positive unless preceded by "-". A decimal point can be entered.

The CLEAR NUMBER key to the right erases all the numbers entered. It is used to correct a mistake.

Entry of a number does not have any effect until an action key is pressed — either GO-ON or SELECT.

ANNEX 2

LESSON DEVELOPMENT CENTER

A unique and central concept of the Lincoln Terminal System is the Lesson Development Center (LDC). These centers serve two major functions: (1) the development and validation of new lesson material or the conversion of existing material to meet requirements, and (2) coordination of the continuing evolution of the system. The Center organization and operation should evolve naturally from the research and development program that supports initial field operation. It provides a means to absorb these activities and implement continuing operational responsibility for coordination and growth.

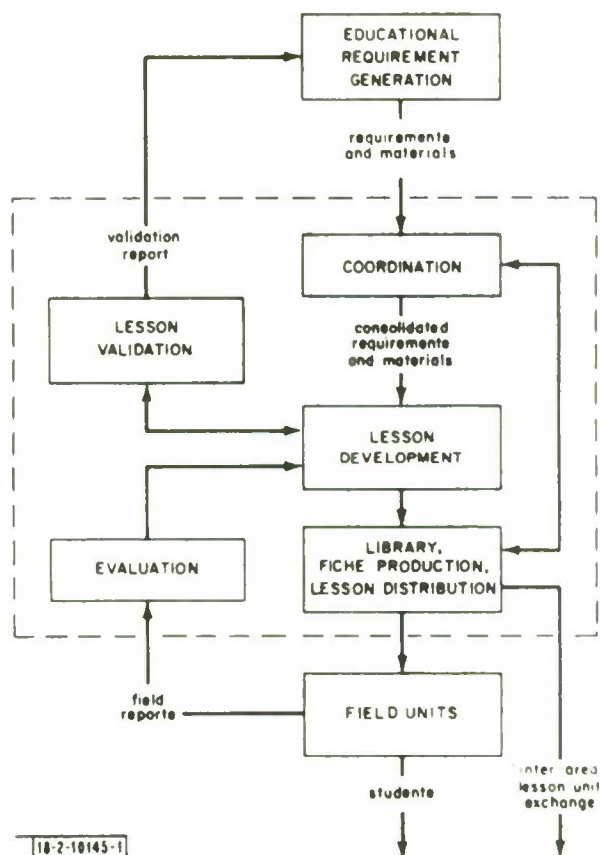
In a full-scale implementation, the LDC might be a regional center or be dedicated to a particular educational area such as medicine or learning disabilities. It could be associated with a particular population such as prisons or VA hospitals. However set up, it would carry out the functions shown in the flow chart (Fig. A-4) to select, develop, and distribute instructional material to user organizations.

Training requirements are generated in the normal fashion and transmitted with supporting material to the Center. Lesson units may be developed by contract, by staff authors permanently assigned to the LDC, or by an author/teacher from the user organization assigned temporarily to the Center during the course of the lesson unit development. Visiting authors may assist or supervise lesson unit preparation depending on the specific case.

When a training requirement is received by the Center (in the form of a statement of learning objectives), a library search is conducted to see if similar lesson units exist; if they do, the requesting agency is asked to review the existing material to determine the relevance of all or part of that material. If it is determined that suitable material is not available at the Center, a search may be made elsewhere for material which provides a suitable base or framework for conversion to LTS format. If nothing is found, the Center undertakes an original development.

The actual lesson development requires the services of professionals who are subject matter experts with a practical understanding of the learning

Fig. A-4. Information flow: Lesson Development Center.



process, the perseverance and patience to expend the effort that is necessary to develop a multi-track lesson, and a precise manner of thinking which prevents omissions or unplanned redundance in the lesson. They must also understand how to make optimal use of the audio-visual combinations and control logic available to them.

The production of lesson unit master fiche and the copying of these fiche to obtain distribution copies are, of course, functions of the LDC. The master fiche is made by photographing photo-ready visual (text, pictures, diagrams) material and audio-logic tracks with a step-and-repeat camera system. This camera is similar to those used to convert thousands of government reports to microfiche. The LTS format requires an extra step in preparing photo-ready copy, since each visual image has a corresponding audio image. Specially constructed electro-optical equipment is required to produce the audio track and to merge the lesson control logic onto that track in a form which permits it to be treated

as if it were a standard visual image. Once the master fiche is made, diazo or silverhalide copy prints may be made in conventional automatic copiers.

When lesson unit distribution copies are available, validation trials are initiated at the LDC, or under supervision at the user agency, or both. Once validated to the degree required for initial use, the lesson unit may be distributed for full-scale field operation and evaluation. In this connection, it should be emphasized that one of the chief advantages of microfiche publishing is that lesson unit printing and distribution may be done on demand. It is not necessary to maintain large inventories or to guess the size of any given edition (USAFI keeps an inventory worth approximately 75 percent of its annual issue to students in order to meet demand).

A system of periodic field reports summarizing salient operational accomplishments and failures in each lesson unit might be established. These reports would be used as the basis for lesson modification and subsequent re-issue of an improved lesson unit. The inherent modularity of microfiche makes revision a rapid and inexpensive process.

ANNEX 3

The following pages are course outlines of Air Force courses in which the content of interest to the civil sector is high. In many of these courses the equipment requirements in the advanced blocks are restrictive. Earlier sections could be used alone, however, and in fact for the student population we are considering, the more basic sections are probably the most appropriate.

Weather Observer													
Wks: Hrs	1	2	3	4	5	6	7	8	9	10	11	12	13
1	<p>Course Material - UNCLASSIFIED BLOCK I - Surface Weather Observations - 124 Hrs. Orientation and How to Study (4 Hrs); Air Force Mission and Organization and Security (4 Hrs); Cloud Forms (15 Hrs); Ceiling, Sky Condition, and Obscuring Phenomena (20 Hrs); Visibility and Atmospheric Phenomena (18 Hrs); Surface Wind (4 Hrs); Types of Observations and Preparation of Weather Records (46 Hrs); Measurement and Critique (13 Hrs).</p>												
2	<p>Course Material - UNCLASSIFIED BLOCK III - Meteorology and Weather Equipment Operation - 119 Hrs. Elementary Meteorology (27 Hrs); Temperature and Humidity Measuring Instruments (6 Hrs); Pressure Measuring Instruments (9 Hrs); Wind Measuring Instruments (3 Hrs); Precipitation Measuring Equipment (1 Hr); Visibility Measuring Equipment (2 Hrs); Cloud Height Measuring Equipment (6 Hrs); Ground Safety Practices (1 Hr); Rawinsonde Equipment and Observations (2 Hrs); Weather Radar Equipment and Observations (34 Hrs); Weather Communication and Equipment (22 Hrs); Measurement and Critique (6 Hrs).</p>												
3	<p>Course Material - UNCLASSIFIED BLOCK II - Plotting Weather Maps and Charts 117 Hrs. Synoptic Code Reports from Land Stations (25 Hrs); Gradient Winds (2 Hrs); Synoptic Code Reports from Ship Stations (10 Hrs); Airways Reports (17 Hrs); Winds Aloft (2 Hrs); Thermodynamic Diagrams (20 Hrs); Constant Pressure Charts (10 Hrs); Aircraft Meteorological Reports (12 Hrs); Local Area Surface Charts (9 Hrs); Measurement and Critique (10 Hrs).</p>												
4													
5													
6													

Non-Academic (Commander's Time)

Weather Observer (cont.)					
Wks Hrs	14	15	16	14	15
1	Course Material - UNCLASSIFIED BLOCK IV - Weather Station Operation - 120 Hrs. EXPLANATION: The students are divided into groups of four (4). Each group is under the guidance of an instructor who acts as station chief. Each group is assigned to a practice weather station which utilizes current weather data and simulates operating conditions. Duty assignment in the station is made on a rotating basis so each student performs all duties normally required of an observer, with the exception of upper air observations. Weather observations, operation of meteorological and communications equipment, and preparation of weather maps and charts (106 Hrs); Measurement and Critique (12 Hrs); Course Critique and Graduation (2 Hrs).				
2					
3					
4					
5					
6					
Wks Hrs	14	15	16	14	15
1	Course Material - UNCLASSIFIED BLOCK IV - Weather Station Operation - 90 Hrs. EXPLANATION: The students are divided into groups of four (4). Each group is under the guidance of an instructor who acts as station chief. Each group is assigned to a practice weather station which utilizes current weather data and simulates field operating conditions. Duty assignment in the station is made on a rotating basis so each student performs all duties normally required of an observer, with the exception of upper air observations. Weather observations, operation of meteorological and communications equipment, and preparation of weather maps and charts (76 Hrs); Measurement and Critique (12 Hrs); Course Critique and Graduation (2 Hrs).				
2					
3					
4					
5					
6					
Wks Hrs	14	15	16	14	15
1	Course Material - UNCLASSIFIED BLOCK IV - Weather Station Operation - 66 Hrs. EXPLANATION: The students are divided into groups of four (4). Each group is under the guidance of an instructor who acts as station chief. Each group is assigned to a practice weather station which utilizes current weather data and simulates field operating conditions. Duty assignment in the station is made on a rotating basis so each student performs all duties normally required of an observer, with the exception of upper air observations. Weather observations, operation of meteorological and communications equipment, and preparation of weather maps and charts (52 Hrs); Measurement and Critique (12 Hrs); Course Critique and Graduation (2 Hrs).				
2					
3					
4					
5					
6					

<div> <div> HOURS WEEKS </div> </div>	Physical Therapy Specialist
1	Non-Academic (Commander's Time)
<div>2</div> <div>3</div> <div>4</div> <div>5</div>	<p><u>Course Material - UNCLASSIFIED</u> BLOCK F-I MEDICAL SERVICE FUNDAMENTALS (3AQR90010) 128 Hours</p> <p>Course Orientation and Administration (5 hrs); Medical Terminology (4 hrs) Anatomy and Physiology (21 hrs); Measurement and Critique (2 hrs); Bandages and Field Dressings (3 hrs); Security and Medical Ethics (2 hrs); Hospital Safety Practices (5 hrs); Vital Signs (6 hrs); Supplies and Equipment (1 hr); Historical Highlights of the USAF Medical Service (1 hr); Mission, Organization and Functions of the USAF Medical Service (1 hr); USAF Medical Facilities (2 hrs); Geneva Conventions (1 hr); Measurement and Critique (2 hrs); Military Sanitation Procedures (1 hr); Emergency Medical Treatment for Hemorrhage (1 hr); Emergency Medical Treatment for Shock (1 hr); Toxic Agents (1 hr); Emergency Medical Treatment for Wounds (2 hrs); Head and Back Injuries (2 hrs); Chest and Abdominal Injuries (2 hrs); Thermal Injuries and Heat Disorders (2 hrs); Fractures and Dislocations (2 hrs); Splint Application (2 hrs); Resuscitation (4 hrs); Medical Aspects of Disaster Medicine (2 hrs); Field Casualty Care (Medical Field Exercise, 41 hrs); Measurement and Critique (3 hrs); Educational Opportunities (2 hrs); Course Administration (1 hr); End of Course Critique (1 hr); Graduation (2 hrs)</p>
<div>6</div> <div>7</div> <div>8</div>	<p><u>Course Material - UNCLASSIFIED</u> BLOCK I - BASIC SCIENCES 90 Hours</p> <p>Orientation (1 hr ; The Physical Therapy Career Field (3 hrs); Psychiatry (4 hrs); Physiology (11 hrs); Introduction to Osteology and Arthrology (2 hrs); Osteology of the Skull and Vertebral Column (4 hrs); Osteology of the Thorax and Pelvis (3 hrs); Introduction to Myology (1 hr); Myology of the Axial Skeletal System (9 hrs); Osteology and Arthrology of the Upper and Lower Extremities (8 hrs); Myology and Neurology of the Upper Extremity (13 hrs); Myology and Neurology of the Lower Extremity (9 hrs); Medical and Surgical Conditions (4 hrs); Neurology (4 hrs); Orthopedic Conditions (4 hrs); Measurement and Critique (10 hrs)</p>
<div>9</div> <div>10</div> <div>11</div>	<p><u>Course Material - UNCLASSIFIED</u> BLOCK II - Modalities 101 Hours</p> <p>Radiation Therapy (21 hrs); Introduction to Hydrotherapy (2 hrs); Hot Packs (4 hrs); Paraffin Bath (4 hrs); Whirlpool Bath, Hubbard Tank, and Moistair Unit (6 hrs); Contrast Baths (3 hrs); Cryotherapy (4 hrs); Therapeutic Procedures (4 hrs); Massage (18 hrs); Electrotherapy (5 hrs); Laboratory Diathermy (11 hrs); Low Frequency Electromedical Currents (6 hrs); Ultrasound Therapy (1 hr); Therapeutic Procedures (4 hrs); Measurement and Critique (8 hrs)</p>

HOURS PER WEEK	Precision Measurement Equipment Specialist
1	Nonacademic (Commander's Time)
2 3 4	<p>Course Material - UNCLASSIFIED BLOCK I - Applied Mathematics 90 Hours</p> <p>Orientation and USAF Calibration program (12 hrs); Basic mathematics (12 hrs); Introduction to algebra (12 hrs); Radicals (6 hrs); Complex numbers (3 hrs); Quadratic equations (3 hrs); Word problems (6 hrs); Logarithms (6 hrs); Decibels and power ratio (12 hrs); Vector concepts (12 hrs); Measurement (6 hrs).</p>
	<p>Course Material - UNCLASSIFIED BLOCK II - DC Circuit Analysis 90 Hours</p> <p>Theory of matter (6 hrs); Electrostatic and magnetic forces (9 hrs); Generating electrical energy by chemical means (6 hrs); Electrical conduction (6 hrs); DC circuits (15 hrs); Complex DC circuits (15 hrs); Electromagnetism (6 hrs); Meter mechanisms (6 hrs); Inductance and capacitance (15 hrs); Measurement (6 hrs).</p>
	<p>Course Material - UNCLASSIFIED BLOCK III - AC Circuit Analysis 90 Hours</p> <p>Alternating current (18 hrs); Simple capacitive AC circuits (12 hrs); Simple inductive AC circuits (12 hrs); Complex AC circuits (13 hrs); Transformers and synchro principles (12 hrs); Complex waveform and voltage dividers (12 hrs); Measurement (6 hrs);</p>
	<p>Course Material - UNCLASSIFIED BLOCK IV - Vacuum Tubes and Solid State Principles and Power Supplies 90 Hours</p> <p>Electron tube theory (12 hrs); Triode tube fundamentals (12 hrs); Additional tube fundamentals (6 hrs); Semiconductor physics (6 hrs); Solid state diodes (6 hrs); PNP and NPN transistors (6 hrs); Operational characteristics of transistors (12 hrs); Power supplies and filters (9 hrs); Voltage regulation (6 hrs); Application of power supplies (6 hrs); Indicating devices (3 hrs); Measurement (6 hrs).</p>

HOURS WEEKS	Precision Measurement Equipment Specialist (cont.)
14 15	<p>Course Material - UNCLASSIFIED BLOCK V - Solid State and Vacuum Tube Amplifiers 60 Hours</p> <p>Direct coupled amplifiers (12 hrs); RC coupled amplifiers (18 hrs); Impedance and transformer coupled amplifiers (6 hrs); Feedback amplifiers (6 hrs); Special circuits (12 hrs); Measurement (6 hrs).</p>
16 17	<p>Course Material - UNCLASSIFIED BLOCK VI - Wave Generating and Shaping Circuits 60 Hours</p> <p>Sinusoidal oscillators (15 hrs); Nonsinusoidal generators (18 hrs); Limiters, clippers, and choppers (9 hrs); Logic circuits (6 hrs); Counter circuits (6 hrs); Measurement (6 hrs).</p>
18 19	<p>Course Material - UNCLASSIFIED BLOCK VII - Microwave Generation and Transmission Line Principles* 60 Hours</p> <p>Microwave generation (12 hrs); Transmission line theory and measurement (18 hrs); Microwave impedance (9 hrs); Square law detectors and detection (3 hrs); Waveguides and resonant cavities (9 hrs); Special applications of transmission lines (3 hrs); Communications security practices - I (1 hr); Measurement (5 hrs).</p>
20 21	<p>Course Material - UNCLASSIFIED BLOCK VIII - Test Equipment Troubleshooting and Repair Procedures 60 Hours</p> <p>Circuit analysis techniques (6 hrs); Logical troubleshooting procedures (3 hrs); Inspection and subassembly isolation of malfunctions (6 hrs); Test equipment troubleshooting - Multimeters (6 hrs); Test equipment troubleshooting - Signal generators (6 hrs); Test equipment troubleshooting - Oscilloscopes (12 hrs); Repair of circuits, printed circuits, cables, and connectors (12 hrs); Replacement parts requisition procedures (3 hrs); Measurement (6 hrs).</p>
22 23	<p>Nonacademic (Mid-Course Leave)</p>

<div> <div>HOURS</div> <div>251</div> <div>WEEKS</div> </div>	Precision Measurement Equipment Specialist (cont.)
<div>24</div> <div>25</div> <div>26</div>	<p>Course Material - UNCLASSIFIED BLOCK IX - DC and Low Frequency AC Measurements I* 90 Hours</p> <p>The metrology of voltage, current, and power (12 hrs); Instrument calibration standard, electrostatic voltmeter, and voltage regulator (18 hrs); Precision voltage and current measurement, decade attenuators, and DC power supplies (15 hrs); Thermal converter meters (9 hrs); Vacuum tube voltmeters (12 hrs); Voltmeter calibration system (9 hrs); Differential voltmeters (9 hrs); Measurement (6 hrs).</p>
<div>27</div> <div>28</div> <div>29</div>	<p>Course Material - UNCLASSIFIED BLOCK X - DC and Low Frequency AC Measurement II* 90 Hours</p> <p>Measurement of resistance (18 hrs); Resistance bridges (21 hrs); Measurement of capacitance, inductance, and reactance (18 hrs); Reactance bridges (12 hrs); Voltage dividers and transformers (9 hrs); Synchro test equipment (6 hrs); Measurement (6 hrs).</p>
<div>30</div> <div>31</div>	<p>Course Material - UNCLASSIFIED BLOCK XI - Wavform Analysis* 60 Hours</p> <p>Oscilloscopes (30 hrs); Analysis of waveforms (6 hrs); Oscilloscope calibrating equipment (12 hrs); Calibration of the oscilloscope (6 hrs); Measurement (6 hrs).</p>
<div>32</div> <div>33</div> <div>34</div>	<p>Course Material - UNCLASSIFIED BLOCK XII - Frequency Measurement* 90 Hours</p> <p>Measurement of frequency and time interval (9 hrs); Frequency meter (30 hrs); Calibration of the frequency meter (6 hrs); Distortion analyzers (6 hrs); Function generators (6 hrs); Low frequency signal generators (6 hrs); Generation and measurement of high frequencies (12 hrs); Phase measuring equipment (9 hrs); Measurement (6 hrs).</p>
<div>35</div> <div>36</div> <div>37</div>	<p>Course Material - UNCLASSIFIED BLOCK XIII - Microwave Measurement I* 90 Hours</p> <p>Fundamentals of microwave measurements (18 hrs); Microwave laboratory equipment (27 hrs); Microwave SWR and impedance measurements (18 hrs); Microwave power measurements (15 hrs); Microwave frequency measurements (6 hrs); Measurement (6 hrs).</p>

HOURS WEEKS	Precision Measurement Equipment Specialist (cont.)
	<u>Course Material - UNCLASSIFIED</u> BLOCK XIV - Microwave Measurement II* 90 Hours
38	Microwave attenuation measurements (18 hrs); Calibration of microwave laboratory equipment (33 hrs); Spectrum analysis (15 hrs); Field trip to National Bureau of Standards at Boulder, Colorado (6 hrs);
39	*3ABR32430-1 Measurement (5 hrs); *3ABR32430-1 - Course Critique and graduation (1 hr);
40	Air Force supply and maintenance management (11 hrs); Communication security practices - II (1 hr); Measurement (6 hrs).
	<u>Course Material - UNCLASSIFIED</u> BLOCK XV - Physical Measurement I 90 Hours
41 42 43	Routine, medium and precision measurements (24 hrs); Optical measurements (18 hrs); Measurement of heat, temperature, and humidity (18 hrs); Rotary and vibratory motion (24 hrs); Measurement (6 hrs).
	<u>Course Material - UNCLASSIFIED</u> BLOCK XVI - Physical Measurement II 90 Hours
44 45 46	Weights and balances (6 hrs); Measurement of force and torque (30 hrs); Mechanical gages, piston gages and dead weight testers (24 hrs); Measurement of pressure and vacuum (24 hrs); Measurement (5 hrs); Course Critique and graduation (1 hr).

<div> <div>HOURS</div> <div>PER DAY</div> <div>WEEKS</div> </div>	Water and Waste Processing	
1	Nonacademic (Commander's Time)	
2	<p>Course Material - UNCLASSIFIED</p> <p>BLOCK I - Introduction to Water and Waste Processing 30 Hours</p> <p>Orientation (2 hrs); Career Field Progression and Training (2 hrs); Communication Security (2 hrs); Technical Publications (6 hrs); Resources and Work Force Management (6 hrs); Basic Mathematics (9 hrs); Measurement and Critique (3 hrs).</p> <p>(Safety as Applicable)</p>	
3 4	<p>Course Material - UNCLASSIFIED</p> <p>BLOCK II - Water and Wastewater Analysis 60 Hours</p> <p>Basic Chemistry (18 hrs); Air Force Water Requirements (2 hrs); Sources and Characteristics of Water (4 hrs); Laboratory Safety (1 hr); Collecting and Labeling Water and Waste Samples (2 hrs); Water Analysis (15 hrs); Wastewater Analysis (12 hrs); Measurement and Critique (6 hrs).</p> <p>(Safety as Applicable)</p>	
5 6	<p>Course Material - UNCLASSIFIED</p> <p>BLOCK III - Operating Principles of Water Treatment Plants 60 Hours</p> <p>Principles of Water Treatment Plants (6 hrs); Clarification (18 hrs); Water System Filters (6 hrs); Chemical Disinfection (4 hrs); Taste, Odor, and Color Control (2 hrs); Fluoridation and Defluoridation (2 hrs); Water Distribution System (4 hrs); Field Water Treatment (12 hrs); Measurement and Critique (6 hrs).</p> <p>(Safety as Applicable)</p>	

HOURS PER WEEK	Water and Waste Processing (cont.)
	<p>Course Material - UNCLASSIFIED</p> <p>BLOCK IV - Specialized Water Treatment Processes 60 Hours</p> <p>7 Ion Exchange and Controls (24 hrs); Electrodialysis Demineralization (4 hrs); Specialized Water Treatment (2 hrs); Distillation (15 hrs);</p> <p>8 Internal Corrosion and Scale (9 hrs); Measurement and Critique (6 hrs).</p> <p>(Safety as Applicable)</p>
	<p>Course Material - UNCLASSIFIED</p> <p>BLOCK V - Waste Treatment and Disposal 60 Hours</p> <p>9 Classes and Sources of Waste (1 hr); Field Sanitation (2 hrs); Composition and Characteristics of Sewage (3 hrs); Principles of Waste Treatment (6 hrs); Primary Waste Treatment (12 hrs); Secondary Waste Treatment (18 hrs); Tertiary Treatment (2 hrs); Chlorination and</p> <p>10 Stream Survey (4 hrs); Industrial and Radioactive Waste (6 hrs); Measurement and Critique (6 hrs).</p> <p>(Safety as Applicable)</p>
	<p>Course Material - UNCLASSIFIED</p> <p>BLOCK VI - Maintenance of Water and Waste Processing System Components 60 Hours</p> <p>11 External Corrosion Control (6 hrs); Cathodic Protection (3 hrs); Drive Equipment and Accessories (9 hrs); Pipeline, Valves, Meters and Recorders (6 hrs); Chemical Feeders (3 hrs); Maintenance of Sewage</p> <p>12 Plant Equipment (3 hrs); Pump Maintenance (12 hrs); Wells and Well Maintenance (9 hrs); Logs and Reports (3 hrs); Measurement and Critique (5 hrs); Course Critique, Driver Safety and Graduation (1 hr).</p> <p>(Safety as Applicable)</p>

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